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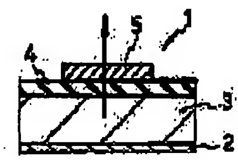
(54) SHORT-WAVELENGTH LIGHT-EMITTING ELEMENT

(57)Abstract:
PURPOSE: To obtain a short-wavelength light-emitting element which generates light at a wavelength of 300nm or lower by a method wherein the short-wavelength light- emitting element is provided with a first diamond layer, with a second diamond layer which is laminated on the first diamond layer and whose resistance is higher than that of the first diamond layer and with a first electrode and a second electrode which are respectively adjacent to the first and second diamond layers.
CONSTITUTION: A short-wavelength light-emitting element is provided with a first diamond layer 3, with a second diamond layer 4 which is laminated on the first diamond layer 3 and whose resistance is higher than that of the first diamond layer 3 and with a first electrode 2 and a second electrode 5 which are respectively adjacent to the first and second diamond layers 3, 4. Then, the peak of the luminous intensity of a luminous spectrum obtained by applying a voltage across the first and second electrodes 2, 5 is situated in a wavelength region of 300nm or lower. For example, a short-wavelength light-emitting element is provided with a first diamond layer 3 which is composed of a low-resistance p-type semiconductor diamond, with a second diamond layer 4 which is formed on the layer and which is composed of a high- resistance diamond and with a first electrode 2 and a second electrode 5 which are made of a metal.



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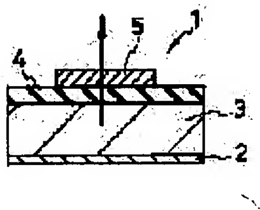
(54) SHORT-WAVELENGTH LIGHT-EMITTING ELEMENT

(57)Abstract:



PURPOSE: To obtain a short-wavelength light-emitting element which generates light at a wavelength of 300nm or lower by a method wherein the short-wavelength light- emitting element is provided with a first diamond layer, with a second diamond layer which is laminated on the first diamond layer and whose resistance is higher than that of the first diamond layer and with a first electrode and a second electrode which are respectively adjacent to the first and second diamond layers.

CONSTITUTION: A short-wavelength light-emitting element is provided with a first diamond layer 3, with a second diamond layer 4 which is laminated on the first diamond layer 3 and whose resistance is higher than that of the first diamond layer 3 and with a first electrode 2 and a second electrode 5 which are respectively adjacent to the first and second diamond layers 3, 4. Then, the peak of the luminous intensity of a luminous spectrum obtained by applying a voltage across the first and second electrodes 2, 5 is situated in a wavelength region of 300nm or lower. For example, a short-wavelength light-emitting element is provided with a first diamond layer 3 which is composed of a low-resistance p-type semiconductor diamond, with a second diamond layer 4 which is formed on the layer and

which is composed of a high- resistance diamond and with a first electrode 2 and a second electrode 5 which are made of a metal.

CLAIMS

【Claim(s)】

【Claim 1】A short wavelength light emitting device comprising:

The 1st diamond layer.

This 1st diamond layer laminates and it is the 2nd diamond layer of high resistance from said 1st diamond layer.

An emission spectrum produced by having the 1st and 2nd electrodes that touch said 1st and 2nd diamond layers, respectively, and impressing voltage to inter-electrode 【 said / 1st and 2nd 】 is a peak of luminescence intensity to a wavelength area of 300 nm or less.

【Claim 2】The short wavelength light emitting device according to claim 1, wherein said each of 1st and 2nd diamond layers are constituted in a cathode luminescence spectrum in a room temperature with a diamond in which recombination radiation of an exciton is observed.

【Claim 3】The short wavelength light emitting device according to claim 1 or 2, wherein said 1st diamond layer is constituted by semiconductor diamond and said 2nd diamond layer is constituted with a undoped diamond.

【Claim 4】The short wavelength light emitting device

according to claim 1 or 2, wherein said each of 1st and 2nd diamond layers are constituted with a semiconductor diamond.

【Claim 5】A short wavelength light emitting device given in any 1 paragraph of claims 1 thru/or 4, wherein either of said 1st and 2nd diamond layers is formed on a member chosen from a group which consists of a diamond crystal, vapor-phase-synthesis diamond membrane, and your kind consideration tropism diamond membrane.

【Claim 6】A short wavelength light emitting device given in any 1 paragraph of claims 1 thru/or 4 which laminating and forming said 1st and 2nd diamond layers on a non-diamond substrate, and dissociating from said non-diamond substrate.

【Claim 7】A short wavelength light emitting device given in any 1 paragraph of claims 1 thru/or 6, wherein said 2nd diamond layer is laminated on a predetermined field of said 1st diamond layer and said 1st electrode is selectively formed on fields other than said predetermined field of said 1st diamond layer.

【Claim 8】A short wavelength light emitting device comprising:

A diamond layer.

An emission spectrum produced by having the 1st and 2nd electrodes that touch this diamond layer, and impurity concentration's changing continuously in a thickness direction of said diamond layer, and impressing voltage to inter-electrode 【 said / 1st and 2nd 】 is a peak of luminescence intensity to a wavelength area of 300 nm or

less.

【Claim 9】A short wavelength light emitting device comprising:
A diamond layer.
Have the 1st and 2nd electrodes that touch this diamond layer, and two or more sets of low concentration impurity regions and high concentration impurity regions where impurity concentration differs mutually in said diamond layer are established in a thickness direction by turns,
An emission spectrum produced by impressing voltage to inter-electrode 【 said / 1st and 2nd 】 is a peak of luminescence intensity to a wavelength area of 300 nm or less.

【Claim 10】The short wavelength light emitting device according to claim 8 or 9, wherein said diamond layer is constituted in a cathode luminescence spectrum in a room temperature with a diamond in which recombination radiation of an exciton is observed.
【Claim 11】A short wavelength light emitting device given in any 1 paragraph of claims 8 thru/or 10, wherein said diamond layer is formed on a member chosen from a group which consists of a diamond crystal, vapor-phase-synthesis diamond membrane, and your kind consideration tropism diamond membrane.
【Claim 12】A short wavelength light emitting device given in any 1 paragraph of claims 8 thru/or 10, wherein said diamond layer is formed on a non-diamond substrate and

separated from said non-diamond substrate.

DETAILED DESCRIPTION

【Detailed Description of the Invention】

【0001】

【Industrial Application】This invention relates to the short wavelength light emitting device formed with the diamond.

【0002】

【Description of the Prior Art】A undoped diamond is an electrical insulator and the band gap is comparatively as large as about 5.5 eV. As a method of forming a diamond artificially, the method of forming diamond membrane by the CVD (vapor phase epitaxy) method is known (JP,59-27754,B).

【0003】How to form a p-type semiconductor diamond by doping impurities, such as B (boron), into a diamond is also known (JP,59-137396,A).

【0004】If vapor phase synthesis of the diamond is carried out on a single crystal diamond board, it is also publicly known that a single crystal diamond thin film can be obtained (the research on a diamond, the National Institute for Research in Inorganic Materials research report No. 39, the Science and Technology Agency, 1984, pp.39-43, and JP,2-233590,A).

【0005】Again, On a silicon substrate, a diamond (100). Or the crystal face of (111). . The formation method of the diamond membrane which carried out orientation and grew

is also known. (M.Rosler, et al. ;2nd International Conference on the Applications of Diamond Films and Related Materials, Ed.M.Yoshikawa.) et al., MYU, Tokyo, 1993, pp.691-696.

[0006]And the light emitting device which uses the diamond membrane formed by these methods is conventionally publicly known. For example, there is an MS (metal/semiconductor diamond) mold, MIS (metal / undoped insulating diamond / semiconductor diamond) mold, or EL (electroluminescence) type light emitting device (henceforth the 1st conventional example) which uses a semiconductor diamond.

[0007]An MIS type light emitting device is shown in drawing 10 (JP,1-102893,A). This light emitting device is constituted by the p type semiconductor diamond layer 51 and the undoped diamond layer 53 formed on this semiconductor diamond layer 51. And the 1st electrode 52 is formed in the undersurface side of the semiconductor diamond layer 51, and the 2nd electrode 54 is formed on the undoped diamond layer 53.

[0008]In the light emitting device constituted in this way, if negative voltage is impressed to the 1st electrode at positive and the 2nd electrode, an electron will be poured into the semiconductor diamond layer 51 via the undoped diamond layer 53, and light will be emitted by recombining with a hole.

[0009]There are also red and a light emitting device (henceforth the 2nd conventional example) which obtains blue or green luminescence by using diamond membrane for

a luminous layer and changing the formation condition (an impurity and the kind of defect) (JP,3-122093,A).

【0010】There is also a light emitting device (henceforth the 3rd conventional example) which formed the luminous layer which consists of a semiconductor diamond of a p type or a n type on the conductive substrate, and formed the undoped diamond layer and the electrode one by one on this luminous layer further (JP,3-222376,A).

【0011】

【Problem(s) to be Solved by the Invention】However, the peak of the emission band intensity of the light emitting device in the 1st conventional example is about 450 nm, and the peaks of the emission band intensity of the light emitting device in the 2nd conventional example are about 350 thru/or 750 nm. The luminescent color in the 3rd conventional example is green white. In such a wavelength area, the high-intensity light emitting device which already uses SiC and GaN is marketed, and there is no predominance which uses a diamond.

【0012】This invention was made in view of this problem, and is ****. The purpose is to provide the short wavelength light emitting device which generates the light of the wavelength below nm.

【0013】

【Means for Solving the Problem】A short wavelength light emitting device concerning the 1st invention of this application is laminated by the 1st diamond layer and this 1st diamond layer, and from said 1st diamond layer The 2nd

diamond layer of high resistance, Having the 1st and 2nd electrodes that touch said 1st and 2nd diamond layers, respectively, an emission spectrum produced by impressing voltage to inter-electrode [said / 1st and 2nd] has a peak of luminescence intensity in a wavelength area of 300 nm or less.

[0014]As for said 1st and 2nd diamond layers, in a cathode luminescence spectrum in a room temperature, it is preferred to be constituted with a diamond in which recombination radiation of an exciton is observed.

[0015]A short wavelength light emitting device concerning the 2nd invention of this application has a diamond layer and the 1st and 2nd electrodes that touch this diamond layer, In a thickness direction of said diamond layer, impurity concentration changes continuously, and, as for an emission spectrum produced by impressing voltage to inter-electrode [said / 1st and 2nd], it has a peak of luminescence intensity in a wavelength area of 300 nm or less.

[0016]A short wavelength light emitting device concerning the 3rd invention of this application has a diamond layer and the 1st and 2nd electrodes that touch this diamond layer, Two or more sets of low concentration impurity regions and high concentration impurity regions where impurity concentration differs mutually in said diamond layer are established in a thickness direction by turns, An emission spectrum produced by impressing voltage to inter-electrode [said / 1st and 2nd] has a peak of luminescence intensity in a wavelength area of 300 nm or

less.

【0017】As for said diamond layer, in a cathode luminescence spectrum in a room temperature, it is preferred to be constituted with a diamond in which recombination radiation of an exciton is observed.

【0018】

【Function】A band gap is 5.5 eV and luminescence with a short wavelength of 300 nm or less which a large thing is the feature and cannot be theoretically generated in other semiconductor materials by recombination radiation as compared with other semiconductor materials is possible for a diamond. However, in the light emitting device for which luminescence intensity used the conventional diamond membrane depending on the height of the quality of a crystal in luminescence for which it has the energy near a band gap in this way, Since the quality of the crystal of diamond membrane is low and the lattice defect density inside a crystal is high, an electron releases energy by a nonluminescent process and luminescence of short wavelength light of 300 nm or less is not obtained. The crystal quality of a diamond layer is raised in this invention.

Therefore, if high tension is impressed to inter-electrode, paying attention to the short wavelength light of sufficient intensity being obtained, this will be applied to a light emitting device.

【0019】In the short wavelength light emitting device concerning this invention, the semiconductor diamond of

a p type or a n type is used as a luminous layer, for example. The case where the semiconductor diamond which introduced p type impurities, such as B, is hereafter used as the 1st and 2nd diamond layers is explained.

[0020]First, the voltage of a negative forward direction is impressed to the 1st electrode at positive and the 2nd electrode. In this case, since the 2nd diamond layer is high resistance, it can impress a strong electric field to this 2nd diamond layer. Thereby, for example through mechanisms, such as tunneling, from the 2nd electrode, an electron is poured in to the 1st diamond layer and emits light.

[0021]In [for example] a cathode luminescence spectrum as said 1st and 2nd diamond layers, By using the diamond layer excellent in the crystal quality that the recombination radiation of an exciton is observed, the emission spectrum which has a peak of luminescence intensity in 300 nm or less of short wavelength conventionally is obtained.

[0022]Like claim 2, the height of crystal quality can be evaluated by observing the recombination radiation of an exciton in the cathode luminescence spectrum in a room temperature. Below, the reason is explained. When an exciton carries out recombination radiation in a crystal and isothermal generally compares the existence of the recombination radiation, and its intensity, the peak intensity of the luminescence falls reflecting the height of the completeness of a crystalline lattice, so that temperature becomes high. This is the same also in a

diamond crystal and the recombination radiation of the exciton can be measured by a cathode luminescence spectrum. When the recombination radiation of an exciton can be observed, the diamond layer has high crystallinity and it can be said that it is quality enough.

[0023]Measurement of cathode luminescence can be carried out using the device which built the collection mirror, the window made from synthetic quartz, the spectroscope, and the photo-multiplier into the electron microscope, for example. That is, when 5 kV and current irradiate with the electron beam of an electron microscope by $3x10^{-8}A$, for example in accelerating voltage, the existence of a light emission peak can be checked by carrying out the spectrum of the light which a diamond emits. The wavelength of a light emission peak serves as a fixed value according to for example, the origins, such as whether light is emitted via the recombination of a free exciton, or to emit light via the recombination of a neutral acceptor restraint exciton.

[0024]Since in the case of a quality diamond layer the lattice defect density inside a crystal is low and it is rare for an electron to lose energy by a nonluminescent process, luminescence with a short wavelength [near the energy of a band gap] of 300 nm or less is obtained. That is, the electron poured into the 1st diamond layer changes from a conducting zone to an electrification child belt, and is recombined with a hole. At this time, the energy which an electron loses is the almost same energy as a band gap, serves as light whose wavelength is about 200 nm, and

is released. When an electron recombines via the level near the band end, the light whose wavelength is about 200 nm is emitted. For example, in emitting the light whose wavelength is 235 nm when it recombines via the level of a free exciton and passing the level of the neutral acceptor restraint exciton about an impurity like B, it emits the light whose wavelength is 238 nm.

[0025]A quality diamond layer can be obtained by using diamond crystal, vapor-phase-synthesis diamond membrane, and your kind consideration tropism diamond membrane as a substrate, and forming a diamond layer on this substrate. Especially the diamond layer formed on your kind consideration tropism diamond is extremely excellent in quality. Your kind consideration tropism diamond membrane refers to what crystal face orientation arranged regularly in the diamond membrane formed on the non-diamond substrate by vapor phase synthesis. After forming said diamond layer on non-diamond substrates, such as Si, it may remove said substrate.

[0026]In this invention, since the 1st diamond layer turns into a luminous layer, this 1st diamond layer needs to be constituted with the semiconductor diamond in which impurities, such as B, were introduced. On the other hand, the 2nd diamond layer may be any of a undoped diamond or a semiconductor diamond.

[0027]By considering it as the structure where the 2nd diamond layer is formed on the predetermined field of the 1st diamond layer, and the 1st electrode was selectively formed on fields other than said predetermined field of

the 1st diamond layer, Since there is no electrode in the undersurface side of the 1st diamond layer, the generated light can be made to emit efficiently from the undersurface side of the 1st diamond layer.

[0028]Even if the impurity concentration in a diamond layer is continuously changed to a thickness direction and it provides a high concentration impurity region (low resistance area) and a low concentration impurity region (high resistance domain), luminescence which has a peak of luminescence intensity in a wavelength area of 300 nm or less can be obtained like an above-mentioned short wavelength light emitting device.

[0029]When a high concentration impurity region and two or more sets of low concentration impurity regions are established in the thickness direction of the diamond by turns, what is called laser light emitting can be obtained again. Also in this case, an emission spectrum has a peak of luminescence intensity in a wavelength area of 300 nm or less.

[0030]

[Example]Hereafter, the example of this invention is concretely described with reference to an attached drawing. Drawing 1 is a sectional view showing the short wavelength light emitting device concerning the 1st example of this invention. The short wavelength light emitting device 1 concerning this example is constituted by the 1st diamond layer 3 that consists of a p-type semiconductor diamond of low resistance, and the 2nd diamond layer 4 that consists of a diamond of the high

resistance formed on this 1st diamond layer 3. And the 1st metal electrode 2 is formed in the undersurface side of the 1st diamond layer 3, and the 2nd electrode 5 is formed in the predetermined region on the 2nd diamond layer 4.

[0031]The 1st and 2nd diamond layers are constituted in the cathode luminescence spectrum in a room temperature by the quality diamond which can observe the recombination radiation of an exciton.

[0032]Next, operation of the short wavelength light emitting device 1 constituted in this way is explained. Negative voltage is impressed to the 1st electrode 2 of the short wavelength light emitting device 1 at positive and the 2nd electrode 5. In this example, since the 2nd diamond layer 4 is formed with the high resistance diamond, a high electric field can be impressed and an electron can be accelerated to high energy. The energy band structure in this case is shown in drawing 2. The 2nd electrode 6 is in contact with the 2nd diamond layer 8, since voltage is impressed, Fermi level 7 of the 2nd electrode 6 rises, as a result the 2nd electrode 6 side becomes high and the electrification child belt level 9 and the conducting-zone level 10 of the 2nd diamond layer 8 incline.

[0033]The 2nd diamond layer 8 is in contact with the 1st diamond layer 11, and has connected the electrification child belt level 12 and the conducting-zone level 13 of the 1st diamond layer 11 to the electrification child belt level 9 and the conducting-zone level 10, respectively.

[0034]The electron in Fermi level 7 in the 2nd electrode

6 passes the 2nd diamond layer 8 through mechanisms, such as tunneling, and is poured in to the 1st diamond layer 11.

[0035]In this case, since the 1st diamond layer 11 is quality diamond membrane, an electron hardly loses energy in a nonluminescent process. Therefore, the electron of the conducting zone 13 is recombined with the electron hole which exists in the electrification child belt of the 1st diamond layer, and emits the light of energy almost equal to a band gap at this time. That is, light with a wavelength of 300 nm or less is emitted.

[0036]The diamond layer can obtain a quality thing by forming on a diamond crystal, a vapor-phase-synthesis diamond, or your kind consideration tropism diamond substrate. To form a diamond layer on non-diamond substrates, such as silicon and metal, it is necessary to optimize the synthetic condition of a diamond and to reduce the density of a crystal defect and a grain boundary.

[0037]Although a common electrical conducting material can be used as an electrode material in this invention, What is necessary is just to form an electrode by an indium stannic acid ghost (ITO), SnO_2, ZnO, SnO_2-Sb, or Cd_2SnO_4, when especially a transparent electrode is required. Light can be made to emit to the upper part of the short wavelength light emitting device 1 via this transparent electrode by using the 2nd electrode as a transparent electrode.

[0038]They are graph charts showing B concentration in the diamond layer of the short wavelength light emitting

device 15 where the sectional view and drawing 3 (b) in which the short wavelength light emitting device concerning the 2nd example of this invention is shown take B concentration along a horizontal axis, and drawing 3 (a) takes the depth from the semiconductor diamond layer surface along a vertical axis, and which starts this example. The diamond layer 16 is formed for example, on the diamond substrate (not shown), and consists of quality diamond membrane which is the p-type semiconductor carried out as for B dope. The 1st electrode 18 and the 2nd electrode 19 are formed in the predetermined region on this diamond layer 16. As the diamond layer 16 is shown in drawing 3 (b), B concentration by the side of the upper surface is low, and B concentration is high by the undersurface side. In the cathode luminescence spectrum in a room temperature, this diamond layer 16 is formed with the quality diamond which can observe the recombination radiation of an exciton.

[0039]In this short wavelength light emitting device 15, predetermined voltage is impressed between the 1st electrode 18 and the 2nd electrode 19. In this case, since the upper surface side of the diamond layer 16 has low B concentration, it is high resistance, and it can impress a high electric field. Thus, by impressing high tension between the 1st and 2nd electrodes 18 and 19, An electron is poured into the undersurface side (low resistance side) by tunneling etc. from the upper surface side (high resistance side) of the diamond layer 16 from the 2nd electrode 19, and when this electron recombines with an

electron hole, light with a wavelength of 300 nm or less is emitted.

[0040]In this example, since the 1st electrode 18 and the 2nd electrode 19 are formed on the diamond layer 16, light is emitted from the undersurface side of the short wavelength light emitting device 15.

[0041]The diamond layer 16 may be used dissociating from said substrate, after forming on a diamond substrate or forming on a non-diamond substrate.

[0042]The sectional view and drawing 4 (b) in which the short wavelength light emitting device which drawing 4 requires for the 3rd example of (a) this invention is shown are graph charts taking B concentration along a horizontal axis and taking the depth from the diamond layer surface along a vertical axis and in which showing B concentration distribution in the diamond layer of the short wavelength light emitting device 20 of this example. As for the diamond layer 22, B concentration is changing continuously in the thickness direction. That is, B concentration by the side of the upper surface is low, and B concentration of the undersurface side is high. This diamond layer 22 is also constituted in the cathode luminescence spectrum in a room temperature by the quality diamond which can observe the recombination radiation of an exciton. The 1st electrode 21 is formed in the undersurface side of this diamond layer 22, and the 2nd electrode 24 is formed in the upper surface side.

[0043]Also in this short wavelength light emitting device 20, the emission spectrum which has a peak of luminescence

intensity in a wavelength area of 300 nm or less can be obtained like the 2nd example.

[0044]Since the electrodes 21 and 24 are formed in the undersurface [of the diamond layer 22], and upper surface side, respectively, as for this short wavelength light emitting device 20, light is emitted to the side.

[0045]They are graph charts in which the sectional view and drawing 5 (b) in which the short wavelength light emitting device concerning the 4th example of this invention is shown taking B concentration along a horizontal axis, and drawing 5's (a's)'s taking the depth from the diamond layer 16 surface along a vertical axis, and showing B concentration distribution.

[0046]This short wavelength light emitting device 25 is the almost same structure as the 2nd example, and the diamond layer 16 is formed in the cathode luminescence spectrum in a room temperature with the quality diamond in which the recombination radiation of an exciton is observed. B doped region (high concentration impurity region) where B was doped by high concentration, and the undoped field (low concentration impurity region) where B is not doped are established in this diamond layer 16 by turns.

[0047]If predetermined voltage is impressed to the 1st electrode 18 and the 2nd electrode 19 of this short wavelength light emitting device 25, an electron is poured into B doped layer via each undoped field, and an electron will recombine with a hole and will generate light with a wavelength of 300 nm or less. Laser light emitting can

be obtained in this example. Light is outputted towards the side of the light emitting device 25 in this case.

[0048]They are graph charts in which the sectional view and drawing 6 (b) in which the short wavelength light emitting device concerning the 5th example of this invention is shown taking B concentration along a horizontal axis, and drawing 6's (a's)'s taking the depth from the 2nd diamond layer 33 surface along a vertical axis, and showing B concentration distribution in the 1st and 2nd diamond layers 32 and 33. In the cathode luminescence spectrum in a room temperature, the 1st diamond layer 32 is formed with the quality diamond in which the recombination radiation of an exciton is observed. As shown in drawing 6 (b), B doped region and the undoped field where B was doped by high concentration are established in this 1st diamond layer 32 by turns. On this diamond layer 32, the 2nd undoped diamond layer 33 that similarly consists of a quality diamond is formed. The 1st electrode 31 is formed in the undersurface side of the diamond layer 32, and the 2nd electrode 34 is formed in the predetermined region by the side of the upper surface of the diamond layer 33.

[0049]Also in this example, the laser beam which has a peak of luminescence intensity in a short wavelength region of 300 nm or less can be obtained like the 4th example.

[0050]Drawing 7 is a sectional view showing the short wavelength light emitting device concerning the 6th example of this invention. In this short wavelength light emitting device 38, after forming the 1st diamond layer

39 carried out, for example on non-diamond substrates (not shown), such as Si, it is the diamond membrane separated from the non-diamond substrate. [of B dope] Pattern formation of the 2nd diamond layer 40 of high resistance is carried out to the predetermined region of the center on this 1st diamond layer 39. The 2nd electrode 41 is formed on this 2nd diamond layer 40. The 1st electrode 42 is formed on the edge of the 1st diamond layer 39. In the cathode luminescence spectrum in a room temperature, the 1st and 2nd diamond layers 39 and 40 are constituted by each with the quality diamond in which the recombination radiation of an exciton is observed.

[0051]Also in this example, the light which has a peak of luminescence intensity in a wavelength area of 300 nm or less is outputted from the undersurface side of the diamond layer 39 like the 1st example.

[0052]Drawing 8 is a sectional view showing the short wavelength light emitting device concerning the 7th example of this invention. B is doped by the 1st diamond layer 45 and the 2nd undoped diamond layer 46 is formed on this 1st diamond layer 45. In the cathode luminescence spectrum in a room temperature, these diamond layers 45 and 46 are constituted by each with the quality diamond in which the recombination radiation of an exciton is observed. And the 1st electrode 44 is formed in the undersurface side of the 1st diamond layer 45, and the 2nd electrode 47 is formed in the almost same size as the 2nd diamond layer 46 on the 2nd diamond layer 46.

[0053]Also in this example, the light which has a peak of

luminescence intensity in a wavelength area of 300 nm or less is outputted in the direction parallel to the plane of composition of the 1st diamond layer 45 and the 1st electrode 44.

[0054]Next, the short wavelength light emitting device concerning this invention is actually manufactured, and the result of having investigated the emission spectrum is explained. The single crystal diamond film was used as a substrate, and the p-type semiconductor diamond layer (p layer) was formed on this substrate with the microwave CVD method. The formation conditions of this p layer are shown below.

[0055]p stratification condition board; -- single crystal diamond reactant gas; -- CH_4 gas: -- mixed gas substrate temperature;800 ** gas pressure;35Torr composition time; 14-hour thickness [of 0.5%, B_2H_6 gas:5ppm, and H_2 gas]; -- in addition 3 micrometers, The impurity concentration of p layer was measured by secondary ion mass analysis (SIMS). As a result, impurity concentration was $10^{19}cm^{-3}$. It checked that p layer was high quality by investigating the cathode luminescence spectrum in a room temperature, and observing the recombination radiation of an exciton.

[0056]Subsequently, the microwave CVD method was used and a undoped diamond layer (i layer) 700 micrometers in diameter was selectively formed on p layer. The formation conditions of this i layer are shown below.

[0057]i stratification conditioned response gas; -- CH_4 gas: -- mixed gas substrate temperature;800 ** gas pressure;35Torr composition time; 2-hour thickness [of

0.5% and H_2 gas 】; -- in addition 0.5 micrometer, It checked that i layer was high quality by investigating the cathode luminescence spectrum in a room temperature, and observing the recombination radiation of an exciton.

【0058】Next, after carrying out pattern formation of the mask for i layer surface with a photoresist film, the ion implantation of the B was carried out selectively. And after removing a photoresist film, heat treatment of 1 hour was carried out at 900 ** in the vacuum.

【0059】Then, an Au electrode 500 micrometers in diameter was formed on i layer with photolithography technology, and the two-layer electrode of Ti/Au was formed on p layer.

【0060】Thus, in the manufactured short wavelength light emitting device, the voltage of -80V was impressed to the Au electrode to Ti/Au electrode, and emission spectrum measurement was carried out from under a single crystal diamond board. This emission spectrum is shown in drawing 9. Drawing 9 is the graph charts which took wavelength along the horizontal axis and took luminescence intensity along the vertical axis. As shown in this drawing 9, the spectrum which has a peak in wavelength of about 238 nm corresponding to the interband transition of a diamond was acquired.

【0061】The short wavelength light emitting device concerning this invention can constitute two-dimensional or three-dimensional one dimension, an array, or a display by being integrated.

【0062】

【Effect of the Invention】In the cathode luminescence

spectrum in a room temperature, the diamond layer is constituted from this invention by the quality diamond in which the recombination radiation of an exciton is observed, and an electron hardly loses energy by a nonluminescent process.

Therefore, luminescence of short wavelength which has a peak of luminescence intensity in a wavelength area of 300 nm or less is obtained.

DESCRIPTION OF DRAWINGS

【Brief Description of the Drawings】

【Drawing 1】It is a sectional view showing the short wavelength light emitting device concerning the 1st example of this invention, and its light-emitting direction.

【Drawing 2】It is a mimetic diagram showing the band structure in this invention.

【Drawing 3】It is a sectional view showing the short wavelength light emitting device concerning the 2nd example of this invention.

【Drawing 4】It is a sectional view showing the short wavelength light emitting device concerning the 3rd example of this invention.

【Drawing 5】It is a sectional view showing the short wavelength light emitting device concerning the 4th example of this invention.

【Drawing 6】It is a sectional view showing the short wavelength light emitting device concerning the 5th

example of this invention.

【Drawing 7】It is a sectional view showing the short wavelength light emitting device concerning the 6th example of this invention, and its light-emitting direction.

【Drawing 8】It is a sectional view showing the short wavelength light emitting device concerning the 5th example of this invention, and its light-emitting direction.

【Drawing 9】They are graph charts showing the emission spectrum of the short wavelength light emitting device concerning the 7th example of this invention.

【Drawing 10】It is a sectional view showing the conventional light emitting device.

【Description of Notations】

1, 15, 20, 25, 30, 38, 43; short wavelength light emitting device

2, 18, 21, 31, 42, 44, 52; the 1st electrode

3, 11, 32, 39, 45, 51; the 1st diamond layer

4, 8, 23, 33, 40, 46, 53; the 2nd diamond layer

5,6,19, 24,34,41, 47, 54; the 2nd electrode

7; Fermi level

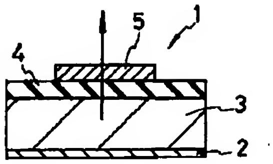
9, 12; electrification child belt level

10, 13; conducting-zone level

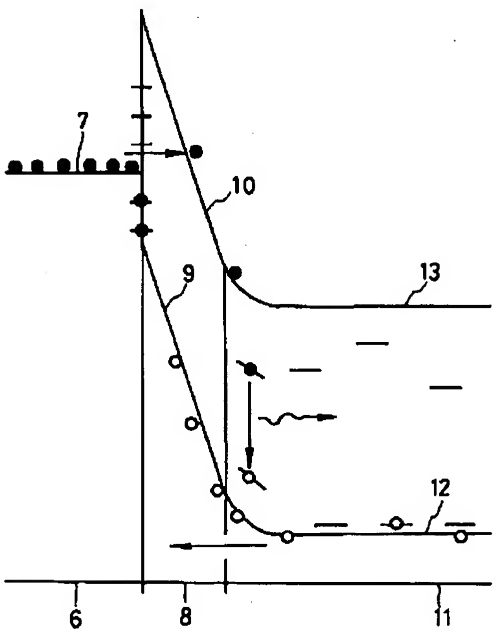
16, 22; diamond layer

DRAWINGS

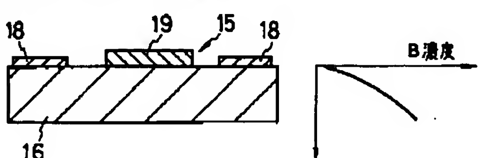
【Drawing 1】



【Drawing 2】

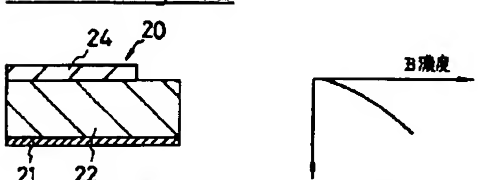


【Drawing 3】



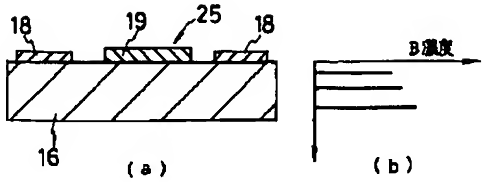
(a) (b)

【Drawing 4】

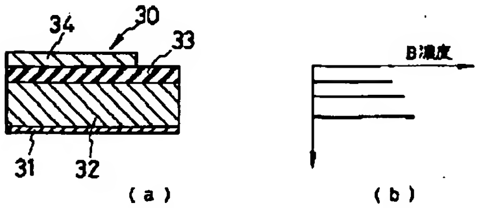


(a) (b)

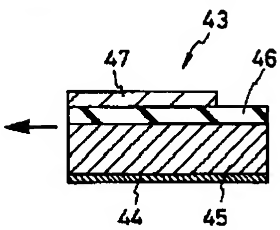
【Drawing 5】



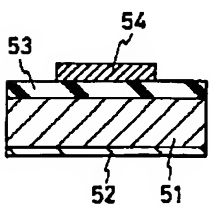
【Drawing 6】



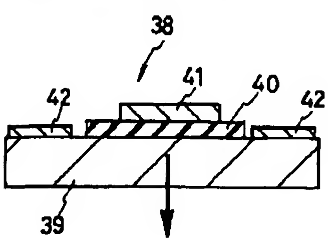
【Drawing 8】



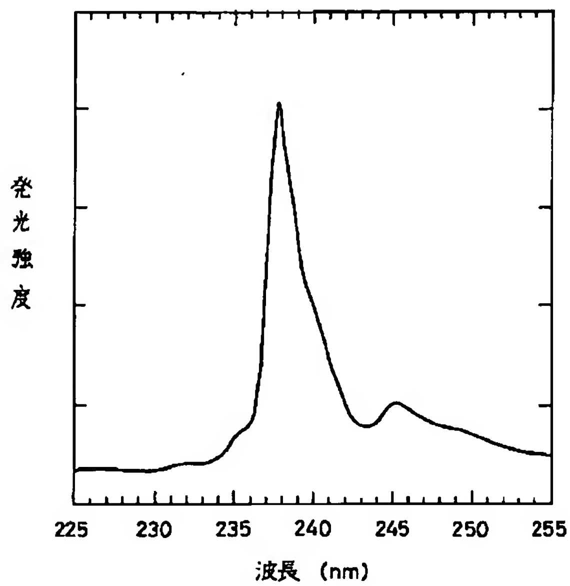
【Drawing 10】



【Drawing 7】



【Drawing 9】



【Translation done.】